EXPLORING THE ASSOCIATION BETWEEN EXECUTIVE FUNCTION AND INCISOR TRAUMA: A PILOT STUDY

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ABSTRACT

Jillian M. Nyquist: Exploring the Association between Executive Function and Incisor Trauma: A Pilot Study
(Under the direction of Lorne D. Koroluk)

Objectives: To explore the relationship between executive function, as assessed by the Behavior Rating Inventory of Executive Function Parent Form Questionnaire (BRIEF®), and incisor trauma in the mixed dentition. Second, to assess other risk factors such as malocclusion, medical/dental history, and daily activities. **Methods:** This pilot study included 2 groups: a test group with history of incisor trauma (n=28) and a control group (n=30) with no history of incisor trauma. Subjects' parents completed the BRIEF® that was scored to assess their child's level of executive function, while a clinical examination was performed to assess subjects' occlusal relationships. Parents completed a customized questionnaire regarding their child's medical history and daily activities. The BRIEF® scores, occlusal characteristics, medical history, and reported daily activities were analyzed to determine if there was a significant difference between the test and control groups using a Fisher Exact and unpaired t-tests. Level of significance was set at 0.05. **Results:** There was a statistically significant difference between the groups with respect to AP dental relationship (p=0.01), with the trauma group having a greater percentage of participants with a Class II molar and canine relationship. There was no significant difference between groups with respect to mean BRIEF® *t*-scores within any of the individual subscales, indices, or Global Executive Composite. However, there was a statistically significant difference with respect to the percentage of subjects with clinically significant (≥65) BRIEF® *t*-scores within

the Inhibit (p=0.05) and Emotional Control (p=0.02) subscales and Behavioral Regulation Index (p=0.02). There were no statistically significant differences between groups with respect to age, gender, overbite, overjet, medical history, BMI, or reported daily activities. **Conclusion:** Those with a Class II relationship are at greater risk for incisor injury, as well as those who are more involved in outdoor activities. There appears to be a link between certain specific executive dysfunctions (i.e. impulsivity and emotional control) and incisor trauma. A larger sample is needed to further investigate the relationship between the multidimensional Executive Function Disorder and incisor trauma.

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LIST OF ABBREVIATIONS

EF	Executive Function
EFD	Executive Function Disorder
BRIEF ®	Behavior Rating Inventory of Executive Function
BRI	Behavior Regulation Index
MI	Metacognition Index
GEC	Global Executive Composite
ADHD	Attention deficit hyperactivity disorder
MI	Maximum intercuspation
BMI	Body mass index

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A REVIEW OF THE LITERATURE

Incisor Trauma in Children

Introduction: Prevalence and Incidence

Incisor trauma is a significant clinical concern in the pediatric population, as it can cause pain and suffering to those affected, require multiple restorative treatments, and ultimately decrease the lifetime longevity of affected teeth in the esthetic zone for these patients. Reported prevalence of incisor trauma in the mixed dentition phase has varied significantly among studies due to differences in methodology, diagnosis, and population sample. Reported prevalence has ranged from less than 6%[1-3] to nearly 50%.[4] However, most studies have found a smaller range of 10-20%.[5-16] The number of studies reporting incidence is much lower than that of studies reporting prevalence and the vast majority of incidence studies have been conducted in Scandinavia. Most of these studies have found the incidence of new traumatic dental injuries in children to be ~ 1.5-4% per year.[17]

Maxillary central incisors are most commonly injured[7,18-20], and most traumatic dental injuries involve a single tooth.[7,18] Trauma prevalence has been shown to be significantly higher in males than females.[1,7,18,19] This is likely attributed to increased participation in riskier activities, including sports, among the male population. Evidence suggests that these dental injuries can have a negative impact on a child's quality of life, due to increased difficulty in eating, interacting, and socializing.[21,22]

Diagnosis/Types of Incisor Trauma

There are several different classification systems used to define traumatic dental injuries: Andreasen, World Health Organization (WHO), Garcia-Godoy, and Ellis. The WHO and Ellis classification systems are most commonly used today and are shown below.

Table 1: Ellis classification of types of tooth fracture[23,24]

Classification	**Clinical Presentation**
Class I	Simple fracture of the crown, involving little or no dentin
Class II	Extensive fracture of the crown, involving considerable dentin but not the dental pulp
Class III	Extensive fracture of the crown, involving considerable dentin and exposing the dental pulp
Class IV	Traumatized tooth becomes nonvital, with or without loss of crown structure
Class V	Total loss of tooth
Class VI	Fracture of the root, with or without loss of crown structure
Class VII	Displacement of the tooth, without fracture of crown or root
Class VIII	Fracture of the crown en masse and its replacement

Table 2. World Health Organization (WHO) classification of dental trauma[25]

Fracture of enamel of tooth
Fracture of crown without pulpal involvement
Fracture of crown with pulpal involvement
Fracture of root of tooth
Fracture of crown and root of tooth

Fracture of tooth, unspecified
Luxation of tooth
Intrusion or extrusion of tooth
Avulsion of tooth
Other injuries including laceration of oral soft tissues

Crown fractures and luxations are the most commonly occurring of all dental injuries. [26] Artun et al. found that 90.3% of injuries in their sample population were unrepaired enamel or enamel/dentin fractures.[18] Other authors have reported that enamel only fractures were most prevalent[7,8,12,27], while Celenk et al. found that enamel-dentin-pulp fractures leading to loss of vitality were the most common.

Luxation is defined as the displacement of a tooth, due to trauma, in any direction. Different types of luxation injuries are listed below.

Table 3: Luxation Injuries[26]

Luxation Injury	**Clinical Findings**
Concussion	Tooth is tender to touch or tapping; it has not been displaced and does not have increased mobility; sensitivity tests are usually positive
Subluxation	Tooth is tender to touch or tapping; increased mobility; no displacement; bleeding from gingival crevice may be noted; sensitivity test may be negative initially indicating transient pulpal damage
Extrusive luxation	Tooth appears elongated and is excessively mobile; sensitivity tests are likely negative

Lateral luxation	Tooth is displaced, usually in the palatal/lingual or labial direction; will be immobile and percussion usually gives high, metallic (ankylotic) sound; fracture of alveolar process present; sensitivity tests are likely negative
Intrusive luxation	Tooth is displaced axially into alveolar bone; immobile and percussion may give high, metallic (ankylotic) sound; sensitivity tests are likely negative

Though less common than fractures and luxation injuries, avulsion of permanent teeth is another type of dental injury that can be extremely detrimental to the survival and longevity of affected teeth. Avulsion, defined as the complete displacement of a tooth from its socket in alveolar bone due to trauma, is one of the most serious dental injuries, and a prompt and correct emergency management is crucial for the prognosis of the tooth.[28] Depending on the type and severity of the orofacial injury, it is common to see different types of dental trauma in the same patient.

Treatment of Incisor Trauma

Proper diagnosis, treatment planning, and follow up care are important for improving the prognosis for traumatic dental injuries. Simple crown fractures that involve enamel only may be treated by bonding the tooth fragment if it is available or restoring missing tooth structure with composite. An enamel-dentin fracture may also be treated by bonding the tooth fragment if it is available. Otherwise, it is recommended that fractures be restored with composite resin, covering the exposed dentin with glass ionomer. If the exposed dentin is within 0.5 mm of the pulp, it is also recommended to place calcium hydroxide base before restoring. If a fracture involves not only enamel and dentin, but also the pulp, protecting the vitality of the pulp becomes a major consideration. In younger patients with immature teeth that are still

developing, pulp capping or partial pulpotomy is recommended to preserve the pulpal vitality. In patients with mature apical development, root canal treatment is recommended in most cases, although pulp capping or partial pulpotomy may also be done. [26]

Concussion and subluxation injuries usually do not require treatment. However, for the latter, a flexible splint may sometimes be used to stabilize the tooth for patient comfort for up to 2 weeks. In extrusive and lateral luxation injuries, it is recommended to reposition the tooth and stabilize it for 2 weeks using a flexible splint. If pulp necrosis is anticipated, root canal therapy is indicated. When evaluating intrusive luxation injuries, it is important to consider the stage of root development of the affected tooth. With incomplete root formation, it is recommended to allow re-eruption without intervention, initiating orthodontic repositioning if no movement is noted within a period of time. If it is intruded more than 7 mm, the tooth should be repositioned surgically or orthodontically. If the affected tooth has complete root formation, management is similar but there is a higher anticipation that the pulp will likely become necrotic. Therefore, root canal therapy using a temporary filling with calcium hydroxide is recommended and treatment should begin 2-3 weeks after surgical repositioning. It is important to stabilize the affected tooth with a flexible splint for 4-8 weeks after surgical repositioning.[26]

Treatment for avulsed teeth varies greatly depending on whether the apex is open or closed, amount of time outside of the tooth socket, and pre-office management of the displaced tooth. Most importantly, it is crucial to minimize the amount of time an avulsed tooth is outside of its socket. If the apex is closed, root canal treatment is indicated and it is recommended to begin this therapy 7-10 days post-replantation.[28]

Though most traumatic dental injuries are coronal enamel fractures[7,8,12], the pulpal prognosis with any traumatic dental injury is always more guarded than it was previously. These injuries commit pediatric patients to a lifetime of restorative management of affected teeth, with accruing associated costs. With more severe injuries, the lifetime longevity of these teeth may be severely compromised.

Long Term Prognosis, Cost, and Time Consequences

Traumatic dental injuries commit a patient to significant financial and time costs. Glendor et al. found that, on average, direct (treatment) time represented 11% and 16% of the total time required for treatment and follow up for primary and permanent teeth, respectively, during a 2 year period. The direct costs (health care services, transportation, medicine, etc.) represented 60% and 72% of the total costs, respectively. Transportation was reported as the most significant indirect time variable, representing about one third of the total time required. Actual total time was estimated to be about 7 and 16 hours for primary and permanent teeth, respectively, while complicated cases required more than twice the time of uncomplicated ones.[29]

The degree of severity and access to treatment are major factors that influence the time and costs of pediatric dental trauma. Nguyen et al. reported that the average treatment cost and direct time (treatment visits) for the first year following replantation of a permanent incisor was $1,465 and 7.2 hours, respectively. Additionally, 90% of patients and 86% of parents stated that some school and work time had been lost.[30] Al-Jundi estimated that the number of visits needed to treat late presenting traumatic dental injuries at a dental teaching hospital ranged between 3 and 17.2, depending on the type of treatment, reporting apexification to be the most time

consuming. It was further noted that almost half of the teeth with luxation injuries became necrotic after 3 years, while previously avulsed teeth continued to deteriorate at the 36-month follow-up appointment.[31]

While it is difficult to estimate absolute costs for traumatic dental injuries due to the many factors that contribute and the long term follow up required, Locker reported estimates of $1,088 and $262, on average, for the United States and Canada, respectively, not taking into account re-injury episodes.[32] Cohen and Cohen considered the following factors when estimating the lifetime cost of a traumatic dental injury treatment: type of dental repair required, frequency of replacement, current and projected dental fees, life expectancy of patient and number of expected replacements of prosthesis, and patient's age at the time of injury. Taking these factors into consideration, the authors found the estimated lifetime cost for replacing permanent maxillary central incisors to exceed $200,000 in a case of a 17 year old following a car accident.[33]

The temporary nature of many traumatic dental injury restorations contributes to the ongoing costs for patients. Robertson et al. retrospectively studied the long term results of treatment for injured teeth following acute trauma. In the review of 488 injured teeth over 15 years, 19% of the composite restorations had been replaced more than 10 times and 25% were deemed unacceptable at the final examination, indicating the need for further treatment.[34] It appears that there is still a need for a longer lasting restorative option for injured teeth.

Understanding the risks associated with dental trauma is important so that early preventive interventions can be attempted. The identification of risk factors for incisor trauma

could lead to the development of an accurate prediction tool that would aid in identifying children at high risk before trauma has occurred.

Risk factors associated with Incisor Trauma

Many studies have investigated the risk factors associated with incisor trauma in young children over the past several decades. These studies have focused on the associated age, sex, occlusal characteristics, and daily behaviors that may increase a child's risk for incisor trauma. In addition to males being at greater risk[1,7,18,19], other risk factors include: increased overjet[5,7,12,18,35-37], inadequate lip coverage[5,7,37], increased protrusion[3,14,38], and a Class II malocclusion[3,14]. Burden et al. found that children with an overjet greater than 3.5 mm have a significantly increased risk of sustaining traumatic injury to their incisors. Studies have shown that the majority of traumatic injuries to anterior teeth are caused by falls or collisions.[16,18,19,39,40] Celenk et al. found the following etiologic factor distribution in their sample population[19]:

Table 4: Distribution of traumatic injuries according to etiologic factors[19]

Etiology	**% of Patients**
Falls or collisions	44.71
Auto-bicycle	18.26
Sports	14.42
Fights	12.01
Nonaccidental	8.05
Unknown	1.92

Artun et al. found that 63% of traumatic dental injuries in their sample occurred in children 10 years of age or older.[18] Celenk et al. found that the age group most commonly

suffering crown fractures was 9-11 year olds.[19] Several studies have found that traumatic dental injuries most often occur in children between ages 10-12[11,13,16], while others have reported a younger peak in trauma between ages 8-10.[40,41] This evidence suggests that the mid-late mixed dentition period appears to be the highest risk dental age for incisor trauma.

While many studies have looked at the occlusal, soft tissue, and skeletal relationships that serve as risk factors for incisor trauma, very few studies have focused on cognitive risk factors that may influence one's behavior and therefore their potential risk for injury. In 1997, the Health Survey for England provided initial data linking hyperactivity to major injuries of the face and/or teeth.[42] Hyperactivity is a symptom of several behavioral disorders such as attention-deficit/hyperactivity disorder (ADHD), anxiety disorders, and mania and should be considered along with age appropriate hyperactivity.[43] Following this, an explanatory model was proposed by Sabuncuoglu et al. who found a significant association between attention deficit/hyperactivity disorder (ADHD) and traumatic dental injuries.[43] ADHD is the most common developmental psychiatric disorder, affecting 4-12% of all school age children. Hyperactivity, inattentiveness, and impulsivity, all fundamental behavioral characteristics of this disorder, become evident by age 7. An important feature of ADHD is accident proneness, which can easily put affected children at risk for serious bodily injury and traumatic dental injuries. Studies have shown that individuals with ADHD often have deficits in their executive functioning, and are therefore said to have Executive Function Disorder.[44]

Executive Function

Definition

Executive function (EF) is one's ability to choose appropriate actions that guide behavior within the context of rules to achieve goals or complete tasks.[45] Essentially, it is our ability to plan, accomplish tasks, organize our daily lives, and control our emotions and impulses. Critical components of executive function include: Initiation, planning, shifting of thought or attention, organization, inhibition of inappropriate thought or behavior, and adequately focused, sustained and sequenced behavior are all critical components to an individual's executive function.[46] Another important aspect of executive function is an individual's ability to check their own work for mistakes and learn from these mistakes moving forward.[47] As EF is composed of many domains, an affected individual may exhibit deficits in all or any of these domains.

Executive Function Disorder (EFD) is a characteristic feature in a spectrum of clinical disorders in children, including those with learning disabilities, low birth weight, attention-deficit/hyperactivity disorder (ADHD), Tourette syndrome, traumatic brain injury, or pervasive developmental disorders/autism.[46] Children with Bipolar Disorder have also been shown to display executive dysfunctions.[48]

The growing literature has consistently documented that children with attention-deficit/hyperactivity disorder (ADHD) exhibit executive function deficits. Pennington and Ozonoff concluded that children with ADHD repeatedly perform worse on certain cognitive and executive function measures after reviewing the literature of 18 studies.[44]

Prevalence and Diagnosis

As Executive Function Disorder is a spectrum disorder, about 15% of children have some degree of executive function deficits. About 30% of children and adults with ADHD have

problems with executive functioning. EFD is very common in children with autism and Fetal Alcohol Syndrome (FAS), among other disorders. Children with brain damage related to delayed growth in-utero or those who were born very prematurely commonly experience difficulties with executive function. Brain injuries associated with infections and tumors may also result in executive dysfunction.[45]

The most comprehensive method to assess a child's executive functioning is a thorough neuropsychological evaluation consisting of a set of tests, questionnaires, interviews, and observations to assess a child's strengths and weaknesses. These tests typically investigate how a child completes tasks and processes information over several sessions. Most clinicians spend 8-9 hours face-to-face with the child, at least an hour or two interviewing parents, and additional time interviewing the child's teachers.[44]

There are two types of screening tests that have been developed to assess executive function and identify at risk children without doing a thorough neuropsychological evaluation, both of which are included in the thorough evaluation. The first type is a questionnaire that asks parents, teachers, and sometimes the school psychologist to report observed behaviors of a child by filling out a rating scale. The BRIEF® is an example of this type of test. The other type of assessment is conducted by a psychologist who observes the child perform a series of tasks and takes note of how he or she approaches each task. The Cognitive Assessment System (CAS) is an example of this kind of test. Clinicians have found that a questionnaire about a child's behavior tends to be more accurate at identifying executive dysfunctions, as children can often function better when isolated in a controlled setting such as a doctor's office, whereas

functioning in the real world can prove to be more difficult with its surrounding distractions and interruptions.[49]

Treatment

Unfortunately, executive function deficits are much less responsive to medications, unlike hyperactivity and inattentiveness. In contrast to ADHD, there is limited research on how psychiatric medications may affect executive functioning in children. The two main types of non-pharmacologic treatments for EFD are: brain exercises and linking the child's brain to someone else's. Examples of brain exercises include memory games, switching back and forth between two activities, and problem solving. Behavior modification programs such as token systems and daily report cards can be used to track and encourage a child's progress on daily tasks and assignments. Caregivers of children with EFD need to be aware of these deficits and understand them thoroughly so that they can assist the child in finding personal solutions to improve behavior and performance outcomes. Parents of children with EFD should seek the help of pediatric neuropsychologists, who can advise them on exercises that will improve daily functioning for affected children.[50]

Behavior Rating Inventory for Executive Function (BRIEF®) Parent Form Questionnaire

The BRIEF® is designed to address the multidimensional nature of executive function. There is a parent and teacher version of this report that can be used to evaluate children. The BRIEF® does not directly measure exact levels of executive function; rather, it reflects the respondents' perceptions of a child's behaviors. The BRIEF® assesses eight subscales of EF: inhibit; shift; emotional control; initiate; working memory; plan/organize; organization of

materials; and monitor. The clinical subscales of executive function, measured on the BRIEF®, are listed in Table 5 below.

Table 5: BRIEF® Clinical Subscales[47]

Subscale	Description
Inhibit	-assesses inhibitory control (i.e. the ability to inhibit, resist, or not act impulsively) and the ability to stop one's own behavior at the appropriate time - has been demonstrated as a core deficit in ADHD, especially the Predominantly Hyperactive-Impulsive Type
Shift	-assesses the ability to move freely from one situation, activity, or aspect of a problem to another as the circumstances demand -key aspects: ability to make transitions, problem-solve flexibly, switch or alternate attention, and change focus from one mindset or topic to another
Emotional Control	-assesses a child's ability to modulate emotional responses -Poor emotional control may be expressed as emotional lability or emotional explosiveness
Initiate	-measures the ability to begin a task or activity, as well as independently generate ideas, responses, or problem-solving strategies.
Working Memory	-measures the capacity to hold information in mind for the purpose of completing a task

	-essential to carrying out multistep activities, completing mental arithmetic, or following complex instructions
Plan/Organize	-measures the child's ability to manage current and future-oriented task demands -Plan component measures ability to anticipate future events, set goals, and develop appropriate steps ahead of time to carry out a task or activity -Organizing component measures the ability to bring order to information and to appreciate main ideas or key concepts when learning.
Organization of Materials	-measures orderliness of work, play, and storage spaces (i.e. desks, lockers, and bedrooms)
Monitor	-assesses work-checking habits (i.e. whether a child assesses his or her own performance during or shortly after finishing a task to ensure appropriate attainment of a goal)

These eight subscales fall under two broader indices: the Behavioral Regulation Index (BRI), which is a composite of Inhibit, Shift, and Emotional Control, and the Metacognition Index (MI), which is a composite of Working Memory, Plan/Organize, Organization of Materials, and Monitor. These two indices are combined to give an overall score, the Global Executive Composite (GEC). The questionnaire is composed of 86 statements that describe children's behaviors. Examples of these statements are: *Is impulsive, Does not finish long-term projects,* and *Forgets to hand in homework, even when completed*. The parent or teacher is asked to respond to each statement with *Never, Sometimes,* or *Often* in regards to how often the child has had problems with these behaviors over the past 6 months. These responses give raw scores

for the eight clinical subscales of executive function. An electronic scoring system is also available from the test publisher. The raw scores can then be transformed into standard *t*-scores and percentile scores. BRIEF® *t*-scores range from 0-100 and higher scores indicate a higher level of dysfunction. A *t*-score of 65 or greater indicates an abnormally elevated score that is clinically significant.[46]

The normative data for the BRIEF® are based on child ratings from 1,419 parents and 720 teachers from rural, suburban, and urban areas. The clinical sample included children with various developmental disorders or acquired neurological disorders. The BRIEF® has been found to have a high internal consistency (α=.80-.98) and test-retest reliability (*rs*=.82 for parents and .88 for teachers). Studies have shown that children diagnosed with ADHD and/or Tourette syndrome are rated as more impaired than control groups on the primary BRIEF® indices, receiving significantly higher scores on this questionnaire.[45]

Prevention of Incisor Trauma

Dental health care providers have the opportunity to play a key role in preventing traumatic dental injuries by educating young patients and their parents and by implementing preventive protocols. Identifying patients who participate in sports allows the health care provider to recommend and implement preventive protocols to decrease the risk of injury. Helmets, facemasks, and mouthguards have been shown to reduce the frequency and severity of traumatic dental injuries.[51] Early orthodontic treatment has also been suggested as a means of reducing risk of incisor injury in pediatric patients. Early growth modification treatment might decrease incidence of trauma if initiated soon after the eruption of maxillary incisors, and while expected cost of trauma is less in these patients compared to those whose orthodontic treatment

is delayed until the permanent dentition, the expected difference must be balanced with the increased costs associated with 2-phase early orthodontic treatment.[20] In 2000, a predictive index was created to identify the traumatic dental injury risk factors in a variety of sports. The index was based on a defined set of risk factors that predict the chance of injury including demographics (age and gender), dental occlusion, protective equipment (type/usage), velocity and intensity of the sport, level of activity and exposure time, level of coaching and type of sports organization, whether the player is a focus of attention in a contact or non-contact sport, history of previous sports-related injury, and the situation (practice vs. game).[52] A predictive index that not only looks at occlusal and sports related factors, but also cognitive factors, could greatly benefit dental health care providers in their abilities to comprehensively assess and identify high risk patients at a young age.

Conclusion

While many studies have been conducted to identify risk factors for incisor trauma in children, very few have investigated cognitive risk factors. A link has been found between ADHD and incisor trauma. While a significant number of patients with ADHD struggle with executive functioning, one might expect those with EFD to be at an increased risk for incisor trauma. But not all children with ADHD exhibit executive dysfunctions, and not all children with executive dysfunctions have ADHD. To date, there have not been any published studies that have attempted to find a link between Executive Function Disorder and incisor trauma. The purpose of this pilot study is to explore the potential relationship between Executive Function Disorder, assessed through the validated BRIEF®, and incisor trauma in children. Determining whether or not there is link between this disorder and incisor trauma would contribute

significantly to our understanding of the risk factors associated with dental trauma in children. It could also contribute to the development of a diagnostic risk assessment tool that could be used by dental healthcare providers to identify high risk children at an early age and intervene, as needed, to reduce their risk of dental injury.

The secondary aim of this study is to assess other risk factors, such as occlusal relationship (molar relationship, overjet, overbite, and lip competence), medical history, and daily activities (amount of time spent playing organized sports, participating in other outdoor activities, playing video games, etc.) to further evaluate other risk factors that could contribute to a dental trauma risk assessment tool.

Preventative care is imperative to our services as oral health care providers. It is crucial for us to do our best to educate our pediatric patients and their parents about their risk of future dental trauma, recommend early intervention treatment when necessary, and provide mouth guards when needed. It would also be beneficial to be able to identify cognitive deficits in our patients as well. If a diagnostic risk assessment tool identifies cognitive deficits, a referral to a psychologist for further evaluation would be warranted. Psychological intervention can help tremendously with behavior management and may also decrease a child's risk of future injury. The development of a validated and holistic predictive index that includes not only demographic, occlusal, and sports-related factors, but also cognitive factors such as hyperactivity and executive function, would allow dental health care providers to comprehensively assess a patient at a young age to determine their risk for potential trauma and implement preventive protocols as needed.

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EXPLORING THE ASSOCIATION BETWEEN EXECUTIVE FUNCTION AND INCISOR TRAUMA: A PILOT STUDY

Introduction

Incisor trauma is a significant clinical concern in the pediatric population, as it can cause pain and suffering to those affected, require multiple restorative treatments, and ultimately decrease the lifetime longevity of affected teeth in the esthetic zone for these patients. Reported prevalence of pediatric traumatic dental injuries has ranged from less than 6%[1-3] to nearly 50%.[4] However, most studies have found a smaller range of 10-20%.[5-16] Studies have shown that maxillary central incisors are most commonly injured[7,18] and that trauma prevalence is significantly higher in males than females[1,7,18,19], likely attributed to their increased participation in riskier activities, including contact sports. Evidence suggests that traumatic dental injuries can have a negative impact on a child's quality of life, due to increased difficulty in eating, interacting, and socializing.[21,22]

Many studies have investigated the risk factors associated with incisor trauma in young children over the past several decades, focusing on the associated age, sex, occlusal characteristics, and daily behaviors. In addition to males being at greater risk[1,7,18,19], other risk factors include increased overjet[5,7,12,18], inadequate lip coverage[5,7], increased protrusion[3,14], and a Class II malocclusion.[3,14] Studies have shown that the majority of anterior traumatic dental injuries are caused by falls or collisions [16,18,19], putting those who engage in riskier behavior at greater risk of injury. Evidence suggests that the mid-late mixed dentition period is the highest risk dental age for incisor trauma.[11,13,16]

Very few studies have investigated cognitive risk factors for incisor trauma. In 1997, the Health Survey for England provided initial data linking hyperactivity to major injuries of the face and/or teeth.[42] Following this, an explanatory model was proposed by Sabuncuoglu et al. who found a significant association between attention deficit/hyperactivity disorder (ADHD) and traumatic dental injuries.[43] Individuals with ADHD often times have deficits in their executive functioning, and are therefore said to have Executive Function Disorder.

Executive function (EF) is one's ability to choose appropriate actions that guide behavior within the context of rules to achieve goals or complete tasks.[45] Essentially, it is the ability to plan, accomplish tasks, organize one's daily life, and control one's emotions and impulses. Critical components of executive function include: ability to initiate and sustain behavior, inhibit competing actions, select relevant tasks goals, plan and organize problem-solving strategies when necessary, and monitor and evaluate one's own behavior.[49] As Executive Function Disorder is a spectrum disorder, about 15% of children have some degree of deficit. About 30% of children and adults with ADHD have problems with executive functioning.[45]

The primary aim of this study was to explore the relationship between Executive Function Disorder, assessed through the validated Behavior Rating Inventory of Executive Function Parent Form Questionnaire (BRIEF®), and incisor trauma. The BRIEF® is a parent/teacher report that reflects their perceptions of a child's behavior within the past six months.

The second aim of this study was to assess other risk factors, such as occlusal relationships (molar/canine classification, overjet, overbite, and lip competence), medical and dental history, and daily activities (i.e. amount of time spent playing organized spots, participating in outdoor activities).

Determining whether or not there is a link between Executive Function Disorder and incisor trauma would contribute significantly to our understanding of the risk factors associated with traumatic dental injuries in children. The better understanding of these risk factors could contribute to the development of a validated and holistic predictive index that would allow dental health care providers to comprehensively assess a patient at a young age to determine their risk for potential injury and implement preventive protocols as needed.

Materials & Methods

This case control pilot study was reviewed and approved by the Institutional Review Board at The University of North Carolina at Chapel Hill. Pediatric patients in the mixed dentition who had experienced incisor trauma necessitating a dental visit for assessment and intervention were identified by the PI and pediatric residents in the Department of Pediatric Dentistry at the University of North Carolina School Of Dentistry. Patients who had not experienced significant incisor trauma that required intervention were recruited to serve as controls. The inclusion and exclusion criteria are listed in the table below.

	Inclusion Criteria	**Exclusion Criteria**
Test group (With incisor trauma)	- Ages 7-14 years - English speaking patient/parent - Recent incisor trauma requiring dental intervention	- Significant medical history that severely impairs motor function (i.e. history of seizures and physical impairments)
Control group (Without incisor trauma)	- Ages 7-14 years - English speaking patient/parent	- Significant medical history severely impairing motor function (i.e. history of seizures and physical impairments)

	- No history/clinical evidence of incisor trauma requiring dental intervention	- Minor incisor trauma for which follow up care was never sought

Parents of identified subjects were asked to participate; appropriate consent and child assent were obtained. Parents were then asked to complete the BRIEF® An oral examination was performed to evaluate the patient's occlusion (overjet, overbite, molar relationship) and lip competence. To assess overjet, the subjects were guided into maximum intercuspation (MI) during the clinical examination. While in MI, a probe was used to measure the distance from the incisal edge of the most prominent maxillary incisor to the labial surface of the most protrusive lower incisor. Overbite and distance between upper and lower lip at rest was measured directly with a periodontal probe. The participants' height and weight were also recorded to calculate body mass index (BMI) using the Center for Disease Control's web based calculator for children and teenagers. Additionally, the parents were asked to complete a customized questionnaire investigating the patient's daily activities (amount of time spent playing organized sports, participating in other outdoor activities, playing video games, etc), history of dental trauma, and medical history (i.e. history of learning disabilities and medications.)

Each BRIEF® was computer scored to calculate raw scores within each of the eight clinical subscales. These raw scores were then converted to *t*-scores using a conversion table in the BRIEF Professional Manual that took into account each subject's age and gender. The Inhibit, Shift, and Emotional Control subscale raw scores were summed to calculate the Behavioral Regulation Index raw scores, which were then converted to *t*-scores based on age and gender. The Working Memory, Plan/Organize, Organization of Materials, and Monitor subscale

raw scores were summed to calculate the Metacognition Index raw scores, which were then converted to *t*-scores. The raw scores for the Behavior Regulation and Metacognition indices were summed to calculate the Global Executive Composite raw scores, which were then converted to *t*-scores. The Global Executive Composite t-score was used to assess a child's overall relative level of executive function and determine whether or not the child was at risk for Executive Function Disorder, which can only be diagnosed through further testing, including a formal clinical examination by a child psychologist or psychiatrist.

Statistical Analysis

Bivariate analysis using Fisher's Exact test was used to the assess differences between the incisor trauma and control groups with respect to the following variables: gender, age, lip competence, AP dental relationship, overbite, overjet, BMI, medical conditions/medications, and learning disabilities. Unpaired t-tests were used to compare the average number of activities that parents reported their children to participate in at least "fairly often" and BRIEF® *t*-scores (including the eight subscale *t*-scores as well as the BRI, MI, and GEC *t*-score) of the incisor trauma and control groups. Level of significance was set at 0.05.

Results

A total of 58 subjects were enrolled in the study. Fifty six were recruited from the UNC Pediatric Dentistry Department, while 2 were recruited from a local private practice. The average age of subjects was 10.14 years. Twenty-eight subjects had history of incisor trauma, while 30 subjects who had not experienced incisor trauma served as controls. The sample was composed of 25 (43%) males and 33 (56%) females. The most commonly injured incisors were

the maxillary centrals (65.5%). The majority of trauma patients had injured more than one tooth (57.14%). The descriptive and bivariate statistics for the study sample are shown on Tables 8-11.

Table 6. Frequency distribution of traumatic dental injuries

Incisor Type	Number of traumatized incisors	
	n	%
Maxillary laterals	9	16.36
Maxillary centrals	36	65.45
Mandibular laterals	4	7.27
Mandibular centrals	6	10.9

Table 7. Frequency distribution of traumatic injuries according to number of injured teeth

Number of injured teeth	Number of trauma patients	
	n	%
1	12	42.86
>1	16	57.14

Table 8. Descriptive and Bivariate Statistics: Gender, Lip Competence, AP Dental Relationship, Overbite (%), Medical Conditions, Medications, Learning Disabilities, and BMI

Variables		All subjects		Incisor Trauma Group		Control Group		P Value
		n	*%*	*n*	*%*	*n*	*%*	
Gender	M	25	43.1	11	39.29	14	46.67	0.6
	F	33	56.9	17	60.71	16	53.33	
Lip competence	Adequate	52	89.66	24	85.71	28	93.33	0.42
	Inadequate	6	10.34	4	14.29	2	6.67	
AP dental relationship	Class I	21	36.21	5	17.86	16	53.33	0.01
	Class II	33	56.9	21	75	12	40	
	Class III	4	6.9	2	7.14	2	6.67	
Overbite (%)	<0	5	8.62	1	3.57	4	13.33	0.6
	0-25	17	29.31	7	25	10	33.33	
	25-50	17	29.31	10	35.71	7	23.33	

	50-75	10	17.24	5	17.86	5	16.67	
	75-100	9	15.52	5	17.86	4	13.33	
Medical Conditions	yes	21	63.16	8	28.57	13	44.83	0.27
	no	36	36.84	20	71.43	16	55.17	
Medications	yes	16	29.09	7	25	9	33.33	0.56
	no	39	70.91	21	75	18	66.67	
Learning disabilities	yes	10	17.54	3	10.71	7	24.14	0.3
	no	47	82.46	25	89.29	22	75.86	
BMI	Healthy (5-85%)	29	50.88	14	51.85	15	50	0.89
	Overweight (85-95%)	15	26.32	7	25.93	8	26.67	
	Obese (>95%)	13	22.81	6	22.22	7	23.33	

Table 9. Descriptive and Bivariate Statistics: Mean Age, Overjet (mm), and Number of activities participated in at least "*fairly often*"

Variables	All subjects		Incisor Trauma		Control		P value
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	
Patient age	10.14	2.17	10.24	2.19	10.05	2.19	0.74
Overjet (mm)	3.89	2.41	4.29	2.39	3.6	2.25	0.76
Number of activities participated in at least fairly often	3.76	1.59	3.96	1.19	3.42	1.92	0.23
BMI Percentile	66.88	31.02	64.19	31.8	69.3	30.64	0.54

Table 10. Descriptive and Bivariate Statistics: Mean BRIEF® *t*-scores

BRIEF® Subscale *t*-scores	All subjects		Incisor Trauma Group		Control Group		P value
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	
Inhibit	52.1	12.5	55.11	14.47	49.3	9.76	0.08

Shift	50.67	12.94	52	13.35	49.43	12.65	0.45
Emotional Control	48.66	12.23	50.42	14.51	47	9.62	0.30
Initiate	50.07	12.77	51.43	13.46	48.8	12.18	0.44
Working Memory	54.17	13.3	54.25	14.58	54.1	12.23	0.97
Plan/Organize	51.98	12.44	52.21	10.95	51.77	13.87	0.89
Organization of Materials	49.19	11.07	48.89	11.18	49.47	11.14	0.85
Monitor	48.39	13	48.07	13.19	48.7	13.04	0.86
Behavioral Regulation Index (BRI) *Inhibit + Shift + Emotional Control*	49.98	13.13	52.75	14.87	47.4	10.89	0.12
Metacognition Index (MI) *Initiate + Working Memory + Plan/Organize + Monitor*	51.52	12.47	51.04	12.75	51.97	12.39	0.77
Global Executive Composite (GEC) *BRI +MI*	50.03	13.85	51.89	14.05	48.3	13.68	0.32

Table 11: Descriptive and Bivariate Statistics: Percentage of Subjects with Clinically Significant (≥65) *t*-scores

BRIEF® Subscale *t*-scores		All subjects		Incisor Trauma Group		Control Group		P Value
		n	%	n	%	n	%	
Inhibit	<65	51	87.93	22	78.57	29	96.67	0.05
	≥65	7	12.07	6	21.43	1	3.33	
Shift	<65	49	84.48	22	78.57	27	90	0.29
	≥65	9	15.52	6	21.43	3	10	
Emotional Control	<65	53	91.38	23	82.14	30	100	0.02
	≥65	5	8.62	5	17.86	0	0	
Initiate	<65	50	86.21	23	82.14	27	90	0.46
	≥65	8	13.79	5	17.86	3	10	
Working Memory	<65	46	79.31	21	75	25	83.33	0.52
	≥65	12	20.69	7	25	5	16.67	
Plan/Organize	<65	45	77.59	23	82.14	22	73.33	0.53
	≥65	13	22.41	5	17.86	8	26.67	
Organization of Materials	<65	51	87.93	25	89.29	26	86.67	0.99
	≥65	7	12.07	3	10.71	4	13.33	
Monitor	<65	52	89.66	24	85.71	28	93.33	0.42
	≥65	6	10.34	4	14.29	2	6.67	
Behavioral Regulation Index (BRI)	<65	53	91.38	23	82.14	30	100	0.02
	≥65	5	8.62	5	17.86	0	0	

Inhibit + Shift + Emotional Control								
Metacognition Index (MI) *Initiate + Working Memory + Plan/Organize + Organization of Materials + Monitor*	<65	48	82.76	23	82.14	25	83.33	0.99
	≥65	10	17.24	5	14.86	5	16.67	
Global Executive Composite (GEC) *BRI + MI*	<65	51	87.93	23	82.14	28	93.33	0.25
	≥65	7	12.07	5	17.86	2	6.67	

In the incisor trauma group, the average age was 10.24 years and 11 (39.3%) were males. Inadequate lip competence was found in 14.3%. The majority demonstrated a Class II molar and canine relationship (75%). Overbite was most commonly found to be 25-50% (35.7%) and the average overjet was 4.3 mm. The average number of activities participated in at least "fairly often" was 4.0. Medical conditions were reported for 8 (28.6%) subjects, while 7 (25%) subjects reported taking daily medications. Three (10.7%) subjects reported learning disabilities. The majority (51.85%) were "healthy" based on their calculated BMIs. The average BRIEF® Subscale, Index, and Global Executive Composite (GEC) *t*-scores can be found in Table 7. The percentage of subjects with clinically significant (≥65) BRIEF® Subscale, Index, and GEC *t*-scores can be found in Table 8.

In the control group, the average age was 10.05 years and 14 (46.7%) were male. Inadequate lip competence was found in 6.7%. The majority demonstrated a Class I molar and canine relationship (53.3%). Overbite was most commonly found to be 0-25% (33.3%) and the average overjet was 3.6 mm. The average number of activities participated in at least "fairly often" was 3.4. Medical conditions were reported for 13 (44.8%), while 9 (33.3%) subjects reported taking daily medications. Seven (24.1%) subjects reported learning disabilities. Fifty percent of the group had "healthy" BMIs. The average BRIEF® *t*-scores can be found in Table 7.

The percentage of control subjects with clinically significant (≥65) BRIEF® *t*-scores can be found in Table 8.

The incisor trauma and control groups were significantly different with respect to AP dental relationship (p=0.01), with the incisor trauma group having a significantly higher percentage (75%) of subjects with a Class II molar and canine relationship. In this sample, there were no significant differences between the two groups with respect to the following variables: age, gender, overbite, overjet, average number of activities participated in at least "fairly often", medical conditions, medications, learning disabilities, and BMI. While there were no statistically significant differences between groups with respect to individual daily activities, there was a statistically significant difference between the groups with respect to participation in "other outdoor activities" (p=0.02). There was no significant difference between the two groups with respect to average *t*-scores for any of the eight BRIEF® subscales, Behavioral Regulation Index (BRI), Metacognition Index (MI), or Global Executive Composite (GEC). However, a *t*-score of 65 or greater in any of these domains indicates an abnormally elevated score that is clinically significant. There was a significant difference between the two groups with respect to percentage of subjects with clinically significant *t*-scores (≥65) in Inhibit (p=0.05) and Emotional Control (p=0.02) subscales, as well a significant difference between the two groups with respect to the Behavioral Regulation Index (p=0.02).

Discussion

Incisor trauma is a serious concern among the pediatric population because of the functional and esthetic consequences, as well as emotional distress, it causes affected children. Additionally, traumatic dental injuries commit children to the burden of lifetime management

and treatment costs, while decreasing the longevity of affected teeth. Previous studies have shown an increased prevalence of incisor trauma in males[7,19,35,36] and/or those with increased overjet[5,7,12,35,36] and inadequate lip coverage[5,7]. In contrast to these studies, the current study did not find a statistically significant association between gender, overjet, or lip competence with regards to the presence or absence of incisor trauma. Though the trauma group had a greater average overjet and greater percentage of subjects with inadequate lip coverage, these differences were not found to be statistically significant. Maxillary centrals have been shown to be affected most frequently[7,12,19,35], and the current study is in agreement with these findings, as maxillary centrals were most commonly injured (65.5%). There was a statistically significant relationship between AP dental relationship and incisor trauma, with the large majority (75%) of the trauma group having a Class II molar and canine relationship, a finding in concert with those of O'Mullane[13] who reported greater trauma prevalence in Class II patients. In contrast to Rajab et al. who reported that most traumatic dental injuries involved one tooth (69.3%), the present study found the majority of injuries involved more than one tooth (57.1%).

It is interesting to note that while there was a statistically significant difference between groups with respect to AP dental relationship, there was not a statistically significant difference with respect to overjet. This may be due to the fact that some of the Class II subjects may have had a Class II Div II malocclusion, with upright central incisors. Therefore, though these patients had a Class II molar and canine relationship, their overjet was not as increased as one might expect.

Very few studies have looked at cognitive risk factors that may influence one's behavior and therefore their trauma risk. The purpose of this study was to explore the relationship

between Executive Function Disorder, assessed by the BRIEF® Parent Form Questionnaire, and incisor trauma in children. Comparing the average *t*-scores between the trauma and control groups showed that while most of the average *t*-scores were higher in the trauma group, this relationship was not statistically significant in any of the individual subscales, indices, or GEC. A *t*-score of 65 or greater in any subscale, index, or GEC indicates an abnormally elevated score that is clinically significant. When comparing the percentage of subjects with abnormally elevated *t*-scores within each group, there was a significant difference in the Inhibit and Emotional Control subscales, as well as the Behavioral Regulation Index. This suggests that those who have less inhibitory control are at greater risk for incisor trauma. Children with high Inhibit scores are more likely to "engage in more physical activity, inappropriate physical responses to others, and a general failure to think before speaking or acting."[46] An association between the Emotional Control subscale and incisor trauma suggests that those who have poor emotional control are at greater risk for injury. As Behavioral Regulation Index is composed of the Inhibit, Shift, and Emotional Control subscales, it is not surprising that there was also a significant association between abnormally elevated *t*-scores in this index and incisor trauma. A deficit in BRI would likely "lead to difficulty with metacognitive processes that are required to successfully guide systematic problem solving and support appropriate self-regulation."[47]

While Global Executive Composite scores were not significantly different between the two groups, the trauma group did have a higher mean GEC *t*-score and greater percentage of subjects with clinically significant GEC *t*-score, indicating a potential relationship between Executive Function Disorder, on a global scale, and incisor trauma. A clinically significant *t*-score places a child in the 90th percentile or above, therefore a larger sample would allow observation of more children who fall in this small range to determine more conclusively

whether or not there is a significant link between Executive Function Disorder and incisor trauma.

While there were no statistically significant difference between groups with respect to any individual daily activity or average number of activities participated in at least "fairly often", there was a statistically significant difference with respect to participation in "other outdoor activities", as reported by parents on the questionnaire. This indicates that the trauma group was generally more active in outdoor activities, putting them at greater risk for incisor trauma.

The development of a holistic diagnostic risk assessment tool could help dental healthcare providers identify high risk patients at an early age. The combination of a clinical examination (noting overbite, overjet, lip competence, and AP dental relationship) and a questionnaire that would address a child's participation in outdoor activities as well as their history of ADHD, could be utilized and "scored" to determine a patient's category of risk. If further studies show a significant relationship between Executive Function Disorder and incisor trauma, it would be beneficial to incorporate a validated questionnaire, or potentially a select set of key questions, that would highlight a patient's risk for EFD. This holistic tool would allow dental healthcare providers to comprehensively assess patients, considering their malocclusion, participation in activities, and cognitive state, when determining their risk for potential injury. Identifying high risk patients at an early age would motivate and justify the implementation of preventive protocols, such as mouthguards or early orthodontic treatment, to decrease the risk of future injury. If assessment showed significant deficits in a patient's executive function, it would be beneficial to advise further evaluation from a child psychologist. This may lead to an official

diagnosis that, when treated, could improve a child's behavior and therefore decrease their trauma risk.

Limitations

A major limitation to this study is the small sample size. Though it was a pilot study intended to solely explore the potential relationship between Executive Function Disorder and incisor trauma, a much larger sample is needed to further explore and draw any definite conclusions. The study excluded other ethnicities, as the BRIEF® is currently only validated in English, and this limited diversity of the sample. Another limitation of this study was the potential for parental bias upon completion of the BRIEF®. As the BRIEF® is a parent's perception of their child's executive function, it is not an objective observation or medical diagnosis. Further evaluation from a pediatric psychologist would be required to arrive at a diagnosis of Executive Function Disorder.

Conclusions

The present study found a significant relationship between AP dental relationship and the presence of a trauma, indicating those who have a Class II dental relationship are at greater risk for injury. There was no statistically significant relationship between the following variables and the presence of incisor trauma: age, gender, overbite, overjet, daily activities, medical conditions and/or medications, learning disabilities, and BMI. While *t*-scores within the majority of the BRIEF® subscales and GEC were higher in the trauma group, this relationship was not statistically significant in this sample. However, there was a statistically significant relationship between the percentage of subjects with abnormally elevated *t*-scores within the subscales Inhibit and Emotional Control, as well as the Behavioral Regulation Index. This suggests that there is a

link between specific executive dysfunctions (i.e. impulsivity and emotional control) and incisor trauma. A larger sample is needed to further investigate the relationship between the multidimensional Executive Function Disorder and incisor trauma.

Figure 1. Medical/Dental History and Daily Activities Questionnaire

UNIVERSITY OF NORTH CAROLINA

SCHOOL OF DENTISTRY

The Association between Executive Function and Incisor Trauma: A Pilot Study

Medical/Dental History and Daily Activities Questionnaire

CASEBOOK #: ☐☐☐☐

INIT: ☐☐☐

DATE: ☐☐ / ☐☐ / ☐☐☐☐

Directions: **Please write neatly, taking care to stay within the boxes. Please fill circles completely.**

The purpose of this questionnaire is to assess the amount of time your child spends participating in various daily activities and determine whether this is related to your child having experienced dental trauma or not. Your participation is voluntary and your answers will be anonymous and confidential.

Your child's date of birth: ☐☐ / ☐☐ / ☐☐☐☐

Your child's sex: ○ Male ○ Female

1. Has your child been diagnosed with any medical conditions? ○ Yes ○ No

If yes, please list below.

_____

2. Has your child ever taken medications for any of the conditions listed above? ○ Yes ○ No

If yes, please list below.

_____

3. Does your child have a learning disability? ○ Yes ○ No

4. Has your child ever experienced facial or dental trauma/injuries that required a visit to the emergency room or a dentist? ○ Yes ○ No

5. Has your child been seen for more than one such episode of facial or dental trauma that required a visit to the emergency room or a dentist? ○ Yes ○ No

If yes, at what age and how did these injures occur?

Age	**How**
☐☐	_____
☐☐	_____
☐☐	_____

Draft

6. During the average week, how often does your child spend participating in the following activities?

Please fill in one response	Never	Occasionally	Fairly often	Very often
1. Playing sports on an organized team: (i.e. soccer, lacrosse, football, hockey, basketball, etc.)	○	○	○	○
2. Participating in individual athletic activities: (i.e. tennis, golf, gymnastics, horseback riding, etc.)	○	○	○	○
3. Playing video games:	○	○	○	○
4. Playing aggressive video games: (i.e. Call of Duty, Gears of War, Grand Theft Auto, etc.)	○	○	○	○
5. Cycling, skateboarding, and/or rollerblading:	○	○	○	○
6. Playing on a playground:	○	○	○	○
7. Jumping on a trampoline:	○	○	○	○
8. Swimming:	○	○	○	○
9. Participating in other outdoor activities:	○	○	○	○

Thank you for your participation.

Draft

Figure 2. Oral Examination Form

UNIVERSITY OF NORTH CAROLINA

SCHOOL OF DENTISTRY

The Association between Executive Function and Incisor Trauma: A Pilot Study

Oral Examination

CASEBOOK #: ☐☐☐☐

INIT: ☐☐☐

DATE: ☐☐ / ☐☐ / ☐☐☐☐

Directions: **Please write neatly, taking care to stay within the boxes. Please fill circles completely.**

1. Incisor trauma present: ○ Yes ○ No

2. Tooth/teeth involved:

	8	7	6	5	4	3	2	1		1	2	3	4	5	6	7	8	
	○	○	○	○	○	○	○	○		○	○	○	○	○	○	○	○	
R																		L
	○	○	○	○	○	○	○	○		○	○	○	○	○	○	○	○	
	8	7	6	5	4	3	2	1		1	2	3	4	5	6	7	8	

3. Lip competence: ○ adequate ○ inadequate

4. Molar relationship: ○ I ○ II ○ III

5. Canine relationship: ○ I ○ II ○ III

6. Overbite (%):
- ○ less than or equal to 0
- ○ 0 - 25
- ○ 25 - 50
- ○ 50 - 75
- ○ 75- 100

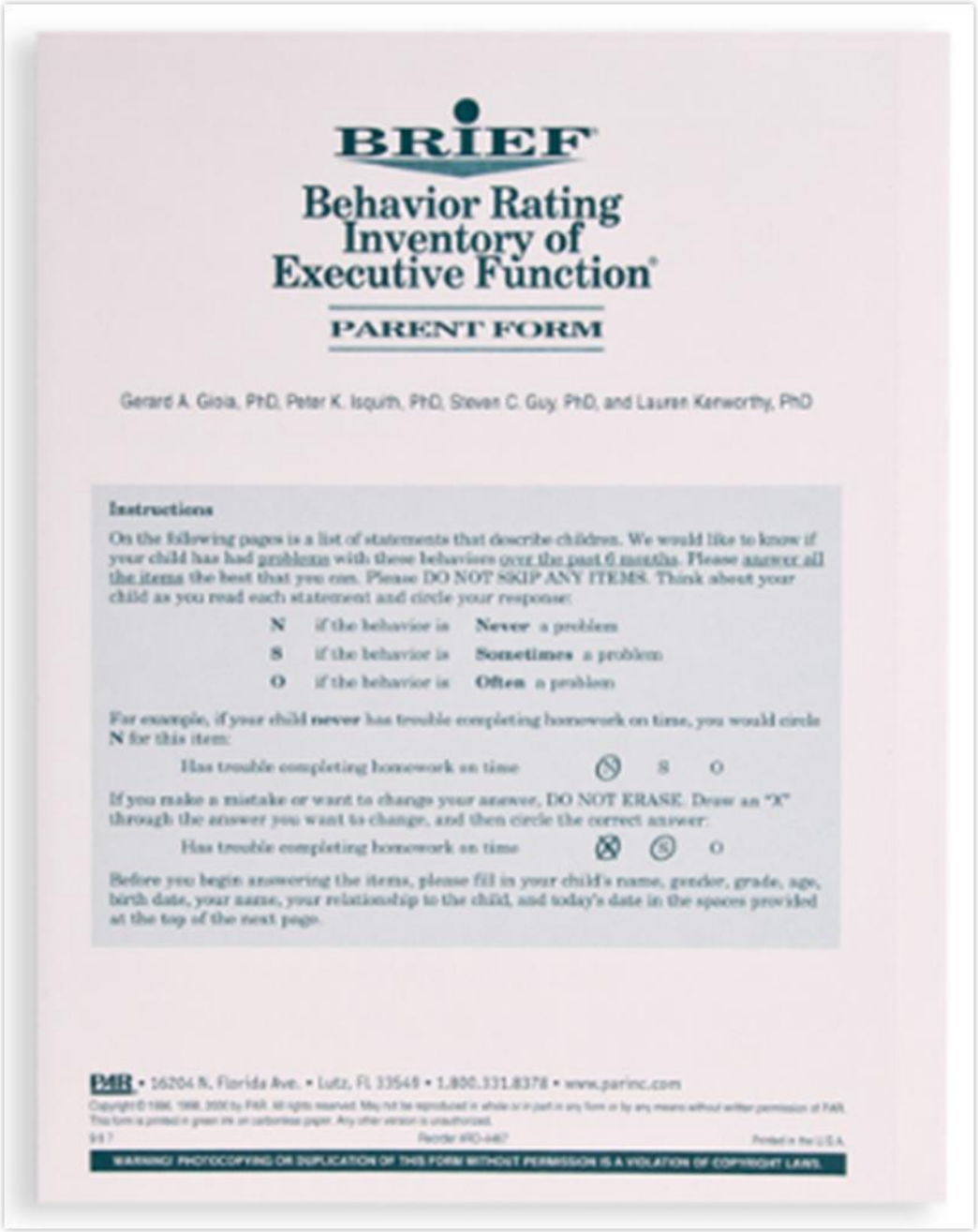
7. Overjet (mm): ☐☐ **mm**

8. Height ☐☐ **inches**

9. Weight ☐☐☐ **pounds**

Draft

Figure 3. BRIEF® Parent Form Questionnaire



BRIEF

Behavior Rating Inventory of Executive Function®

PARENT FORM

Gerard A. Gioia, PhD, Peter K. Isquith, PhD, Steven C. Guy, PhD, and Lauren Kenworthy, PhD

Instructions

On the following pages is a list of statements that describe children. We would like to know if your child has had problems with these behaviors over the past 6 months. Please answer all the items the best that you can. Please DO NOT SKIP ANY ITEMS. Think about your child as you read each statement and circle your response:

N if the behavior is **Never** a problem
S if the behavior is **Sometimes** a problem
O if the behavior is **Often** a problem

For example, if your child **never** has trouble completing homework on time, you would circle **N** for this item:

Has trouble completing homework on time (N) S O

If you make a mistake or want to change your answer, DO NOT ERASE. Draw an "X" through the answer you want to change, and then circle the correct answer:

Has trouble completing homework on time (X) (S) O

Before you begin answering the items, please fill in your child's name, gender, grade, age, birth date, your name, your relationship to the child, and today's date in the spaces provided at the top of the next page.

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Child's Name _____ Gender _____ Grade _____ Age _____ Birth Date____/____/____

Your Name _____ Relationship to Child _____ Today's Date____/____/____

	N = Never S = Sometimes O = Often			
1.	Overreacts to small problems	N	S	O
2.	When given three things to do, remembers only the first or last	N	S	O
3.	Is not a self-starter	N	S	O
4.	Leaves playroom a mess	N	S	O
5.	Resists or has trouble accepting a different way to solve a problem with schoolwork, friends, chores, etc.	N	S	O
6.	Becomes upset with new situations	N	S	O
7.	Has explosive, angry outbursts	N	S	O
8.	Tries the same approach to a problem over and over even when it does not work	N	S	O
9.	Has a short attention span	N	S	O
10.	Needs to be told to begin a task even when willing	N	S	O
11.	Does not bring home homework, assignment sheets, materials, etc.	N	S	O
12.	Acts upset by a change in plans	N	S	O
13.	Is disturbed by change of teacher or class	N	S	O
14.	Does not check work for mistakes	N	S	O
15.	Has good ideas but cannot get them on paper	N	S	O
16.	Has trouble coming up with ideas for what to do in play or free time	N	S	O
17.	Has trouble concentrating on chores, schoolwork, etc.	N	S	O
18.	Does not connect doing tonight's homework with grades	N	S	O
19.	Is easily distracted by noises, activity, sights, etc.	N	S	O
20.	Becomes tearful easily	N	S	O
21.	Makes careless errors	N	S	O
22.	Forgets to hand in homework, even when completed	N	S	O
23.	Resists change of routine, foods, places, etc.	N	S	O
24.	Has trouble with chores or tasks that have more than one step	N	S	O
25.	Has outbursts for little reason	N	S	O
26.	Mood changes frequently	N	S	O
27.	Needs help from an adult to stay on task	N	S	O
28.	Gets caught up in details and misses the big picture	N	S	O
29.	Keeps room messy	N	S	O
30.	Has trouble getting used to new situations (classes, groups, friends)	N	S	O
31.	Has poor handwriting	N	S	O
32.	Forgets what he/she was doing	N	S	O
33.	When sent to get something, forgets what he/she is supposed to get	N	S	O
34.	Is unaware of how his/her behavior affects or bothers others	N	S	O
35.	Has good ideas but does not get job done (lacks follow-through)	N	S	O
36.	Becomes overwhelmed by large assignments	N	S	O
37.	Has trouble finishing tasks (chores, homework)	N	S	O
38.	Acts wilder or sillier than others in groups (birthday parties, recess)	N	S	O
39.	Thinks too much about the same topic	N	S	O
40.	Underestimates time needed to finish tasks	N	S	O
41.	Interrupts others	N	S	O
42.	Does not notice when his/her behavior causes negative reactions	N	S	O
43.	Gets out of seat at the wrong times	N	S	O
44.	Gets out of control more than friends	N	2	O

Subtotals (Items 1-44) –

	N = Never S = Sometimes O = Often			
45.	Reacts more strongly to situations than other children	N	S	O
46.	Starts assignments or chores at the last minute	N	S	O
47.	Has trouble getting started on homework or chores	N	S	O
48.	Has trouble organizing activities with friends	N	S	O
49.	Blurts things out	N	S	O
50.	Mood is easily influenced by the situation	N	S	O
51.	Does not plan ahead for school assignments	N	S	O
52.	Has poor understanding of own strengths and weaknesses	N	S	O
53.	Written work is poorly organized	N	S	O
54.	Acts too wild or "out of control"	N	S	O
55.	Has trouble putting the brakes on his/her actions	N	S	O
56.	Gets in trouble if not supervised by an adult	N	S	O
57.	Has trouble remembering things, even for a few minutes	N	S	O
58.	Has trouble carrying out the actions needed to reach goals (saving money for special item, studying to get a good grade)	N	S	O
59.	Becomes too silly	N	S	O
60.	Work is sloppy	N	S	O
61.	Does not take initiative	N	S	O
62.	Angry or tearful outbursts are intense but end suddenly	N	S	O
63.	Does not realize that certain actions bother others	N	S	O
64.	Small events trigger big reactions	N	S	O
65.	Talks at the wrong time	N	S	O
66.	Complains there is nothing to do	N	S	O
67.	Cannot find things in room or school desk	N	S	O
68.	Leaves a trail of belongings wherever he/she goes	N	S	O
69.	Leaves messes that others have to clean up	N	S	O
70.	Becomes upset too easily	N	S	O
71.	Lies around the house a lot ("couch potato")	N	S	O
72.	Has a messy closet	N	S	O
73.	Has trouble waiting for turn	N	S	O
74.	Loses lunch box, lunch money, permission slips, homework, etc.	N	S	O
75.	Cannot find clothes, glasses, shoes, toys, books, pencils, etc.	N	S	O
76.	Tests poorly even when knows correct answers	N	S	O
77.	Does not finish long-term projects	N	S	O
78.	Has to be closely supervised	N	S	O
79.	Does not think before doing	N	S	O
80.	Has trouble moving from one activity to another	N	S	O
81.	Is fidgety	N	S	O
82.	Is impulsive	N	S	O
83.	Cannot stay on the same topic when talking	N	S	O
84.	Gets stuck on one topic or activity	N	S	O
85.	Says the same things over and over	N	S	O
86.	Has trouble getting through morning routine in getting ready for school	N	S	O

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